Time: 3 hrs. M. M.: 100

N.B.:

1. **All** questions are **compulsory**.
2. **Figures** to the **right** indicate **full** marks.
3. Draw **neat** diagrams wherever **necessary**.
4. Symbols have usual meaning unless otherwise stated.
5. Use of **non-programmable** calculator is allowed.

Constants: Velocity of Light: c =3 × 10^8 meter per second
Planck's Constants: h = 6.63 × 10^{-34} joule second

Q1. Attempt any **two**

(i) Explain the invariance of physical law. Obtain the Galilean transformation for velocity and acceleration and hence shows that force remain invariant under Galilean transformation. **10**

(ii) Explain the length contraction hypothesis. Derive necessary equation. Obtain the volume of cube, when moving with velocity V along one of its edges is parallel to X-axis. The proper length of each edge of cube is l_0. **10**

(iii) Derive the inverse Lorentz transformation equations. **10**

(iv) Using Lorentz transformation equations of space time show that space difference in one frame converted to time difference in another frame and time difference in one frame is converted to space difference. **10**

Q2 Attempt any **two**

(i) Derive Lorentz transformation equations for velocity. Using it show that the velocity of light remains the same in all inertial frames of reference. **10**

(ii) With the help of Minkowski space time diagram explain Relativity of simultaneity and length contraction. **10**

(iii) Derive the relativistic aberration formula using the Lorentz transformation of velocity. **10**

(iv) Derive Lorentz transformation equations for components of acceleration. **10**

Q3 Attempt any **two**

(i) Show that the mass of a particle moving with a speed u is to be defined by $m = \frac{m_o}{\sqrt{1-\frac{u^2}{c^2}}}$ **10**

(ii) Show that, in a region in which there is a uniform magnetic field, a charged particle entering at right angles to the field movies in a circle whose radius is proportional to the particle's momentum. Hence compute the radius, both classically and relativistically, of a 10 MeV electron moving at right angles to a uniform magnetic field of 2 Wb/m^2. **10**

(iii) Using relativistic definition of energy and momentum show that **10**

a) $E^2 = p^2c^2 + m_o^2c^4$

b) $u = \frac{dE}{dp}$

(iv) Obtain the Lorentz transformations of momentum and energy. **10**

Q4 Attempt any **two**

(i) Show that the electric field of uniformly moving point charge in an inertial frame of reference loses its spherical symmetry. **10**

(ii) Derive the expression for force and fields near a current carrying wire. **10**

(iii) Derive the transformation equation for electric field E ⃗ using Lorentz transformation equation for force. **10**

(iv) Show that the Maxwell's equations of electrodynamics are invariant under Lorentz transformation. **10**

Q5. Attempt any **four**

(i) The area of disc in its rest frame is $1m^2$. The disc appears distorted to an observer moving with speed 0.8 c with respect to rest frame along the plane of disc. Find the area measured by an observer. **05**

(ii) Two events separated by spatial distance of $9 \times 10^9 m$ are simultaneous in one inertial frame. What will be the time interval between these two events in another frame moving with velocity 0.8c. **05**

(iii) Write a short note on Twin paradox. **05**

(iv) A source of light of wavelength 6000 AU is approaching an observer with a speed of 0.8c. Find the wavelength of light as observed by the stationary observer. **05**

(v) The earth receives the radiant energy from the sun at the rate of $1.34 \times 10^3\ watts/m^2$. At what rate is the sun losing rest mass due to its radiation? The sun's rest mass is now about $2 \times 10^{30} Kg$. **05**

(vi) Find the mass and kinetic energy of photon of wavelength 5000Å. Take Planck's constant $h = 6.63 \times 10^{34}\ Js$. **05**

(vii) State the postulates of General theory of relativity and explain principle of equivalence **05**

(viii) Obtain the expressions for ρ and $\vec{j}$ in terms of ρ_0. Hence show that $\rho = \left(\frac{\rho_0}{m_0}\right) m;\ \vec{j} = \left(\frac{\rho_0}{m_0}\right) \vec{p}$ **05**
